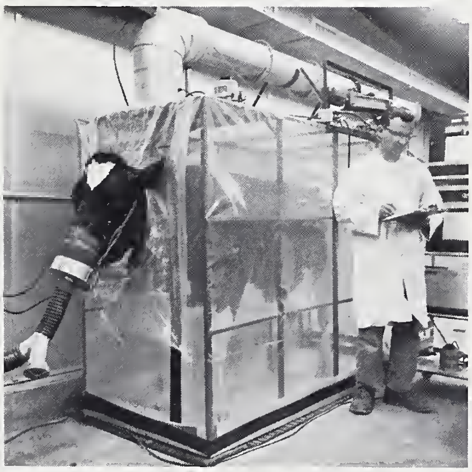
U.S. Department of Agriculture Agricultural Research Service
Nov-Dec 1983

Agricultural Research

30 Years of ARS Research









Only a few research organizations in the United States can trace their origins back 100 years. One is the Agricultural Research Service.

USDA's entry into the research world came in 1862, the year the Organic Act established the Department. Laboratories and bureaus widened the research into new fields over the years. A new agency—the Agricultural Research Service—was established in 1953 as the USDA's chief research organization—the "home" for various laboratories across the country.

ARS has not looked upon 1983 as time to dwell on its 30th anniversary. It had any number of reasons for doing so—especially since the agency had become the world's largest agricultural research organization.

Instead, ARS in 1983 began to rechart its course for the research needs up to and into the 21st century. The guideposts for the agency's new direction are found in the ARS Program Plan (see *Agricultural Research*, Jan-Feb 1983, p. 2).

Says ARS administrator Terry B. Kinney, Jr., "We're building momentum over many years. New technologies such as genetic engineering take time to develop to their full potential. So now is the time to increase the application of these new approaches to both ongoing and emerging problems."

A few numbers show what is in store for agricultural research.

Some projections call for 275 bushels of corn by the year of 2000 and 385 bushels per acre by the year 2050. Such yields equal or exceed the highest experimental yields ever produced and are about three times as high as average farm yields (110 bushels of corn per acre in 1981). Other projections are even higher. And production of crops and livestock is only part of the story. If booming demands are going to be met with radically increased supplies, we will need processing and marketing systems unlike those we know today, to handle them.

Likewise, we need to increase our knowledge of the relationship between food and human health. As the world's leading producer of food, we need to know how our agricultural enterprise influences the health of both our citizens and the citizens of countries that import our farm products.

Scientists and others argue that we have much unused productive capacity—even in light of finite land resources. They point out that because farmers' average crop yields are only a third or less of maximum experimental crop yields, considerable biological potential remains to be exploited.

"This could well tbe true," says Kinney, "and this is why we will not abandon currently successful approaches to ongoing problems. But 30 and 40 years from now, ARS not only wants to be making its full contribution to increased productivity through traditional technologies, but also through science power."

"Science power"—a challenging concept—holds that the complex of modern technologies provides a whole new resource—technology itself—that generates its own unique solutions.

Such a concept piques our imaginations and heightens our expectations. For example, dare we expect that scientists could produce plants that capture extra sunlight or cereal crops that fix nitrogen directly from the air?

To realize these things, however, we must gain the fundamental knowledge and experience necessary to address the constraints that limit agricultural productivity today.

If science power can really boost and maintain overall productivity, can it do so without putting an extra strain on our natural resources? For example, will it be possible to genetically engineer higher-yielding crops that do not also require an increase in nitrogen fertilizer use?

"There is no way to find the answers to these questions without trying," says Kinney. "In other words, there are great risks involved in this research, but there is great potential, too. Given the projections for future needs, there is no way we can *not* take these risks in the hope of success."

At the same time, it is important that ARS persist in transferring its technological knowledge to the agricultural community and responding quickly to immediate problems. ARS scientists will continue to help the private sector adopt the technology that the preceding decades of research have made available. Likewise, ARS's expertise always stands ready to respond to the inevitable unforeseen problems that arise in each growing season.

Says Kinney, "It will be exciting in 30 years to see what progress has come from the new directions we're starting now, and to gauge ARS's approaches to the continuing challenges of the 21st century."

A Sampling of 1983 Research Results

- *Hurricane Alicia blew away buildings and piled up wreckage, but a new rice variety called "Lemont" survived the 115-mile-per-hour winds. "Lemont" lost only 5 percent of its kernels in the summer storm of 1983. Other rice varieties were flattened and stripped of half their kernels.*
- *Housefly embryos have been frozen and brought back to life. Such cold storage could be a way to preserve insect genes carrying beneficial characteristics. It could also preserve rare insect strains for use in biological control strategies against harmful species.*
- *A new technique for measuring vitamin D imbalances opens research avenues to understanding the vitamin's role in metabolic diseases of the kidney, bone, and intestine in animals and humans. Vitamin D imbalances can lead to sickness and death.*
- *A household bleach may one day help turn plant stalks and stems into raw materials needed to make synthetic drugs and plastics. Hydrogen peroxide, the bleach, was found to unlock a natural cement that binds cellulose in plants. If enough cellulose can be freed, it would mean crop residues could be the source of ethyl alcohol for industrial uses.*
- *Infants have been believed to lack the ability to digest cereal starches in the upper intestine. That now appears to be untrue. An infant feeding study shows infants digest starches, suggesting possible revision of infant feeding recommendations in the future.*

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Vol. 32, No. 4
November-December 1983

Editor: Jean M. Rawson
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Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through March 31, 1987. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

Magazine inquiries should be addressed to: The Editor, Information Staff, Room 318, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, Md. 20705. Telephone: (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

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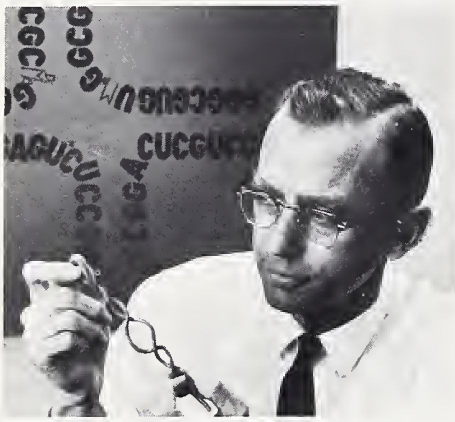
Cover: The work of Agricultural Research Service scientists, engineers, and their many cooperators plays an important part in the history of science for the improvement of agriculture and of life for all. At ARS's 30-year mark we take a look at selected research highlights from the past and the present (p. 4), and at the agency's course for the future. (p. 1).

Milestones in ARS Research

In the pages that follow are some of the milestones of Agricultural Research Service achievements since 1953. Since much significant research was done before then, we have briefly synopsized just a few of these in a separate section within this article.

From these sketches we hope that readers will gain a sense of some of the far-ranging benefits of all *agricultural research, as well as of the scope and purpose of the Agricultural Research Service.—Ed.*

Probing the Mystery of Life...



Biochemist Robert W. Holley with a wire model showing the general configuration of RNA. (Photo by Sol Goldberg, Cornell University) (PN-7076)

The scientific quest to decipher biology's ultimate mystery—How do cells make protein, the building blocks of life?—gained fresh impetus in 1945. It followed announcement of the discovery that a nucleic acid carries and transmits the genetic blueprint for the manufacture of protein. The question matters because how and where cells make protein determine not only why a human differs from a mouse, but also why an individual person is unlike any other on earth.

A big step toward understanding this elemental mystery came in 1965 when a team of five ARS and three Cornell University scientists determined the molecular structure of one of the RNA's, ribonucleic acid. This marked the first time that the structure of an RNA—or any ribonucleic acid—was determined. The achievement won the research team's leader, former ARS biochemist Robert W. Holley, a share of the 1968 Nobel Prize for medicine or physiology. Holley was one of three Americans, working independently, honored for "interpreting the genetic code and its function in protein synthesis."

The research team's achievement was to depict the structure of a "transfer" RNA molecule—designated tRNA—whose function is to carry activated amino acids to protein-building sites within the cell.

For 7 years Holley's team engaged in a kind of molecular cartography. Their working terrain, bundled up inside a tiny yeast cell, was the tRNA molecule. The molecule itself is a chain of smaller organic molecules that can be compared to a string of pearls. Each pearl is strung along a strand composed of a sugary substance called ribose-phosphate. Several organic bases combine with the molecules of ribose-phosphate to form the pearls, which are called nucleotides.

How the nucleotides are arranged along the strand is important because RNA's faithfully follow the DNA molecules' genetic blueprint in assembling the order of amino acids.

The resulting chain of hundreds or even thousands of amino acids is a protein. Arrangement of the nucleotides along the strand also determines the structure of the tRNA molecule.

Holley's team determined the tRNA's structure by using two enzymes to split the molecule into pieces. Each enzyme split the molecule at location points for specific nucleotides. By a process of "puzzling out" the structure of the pieces split by the two different enzymes, then comparing the pieces from both enzyme splits, the team eventually determined the entire structure of the molecule. Since the molecule transports the amino acid alinine to its appropriate protein-building site, it was designated "alinine-tRNA."

By harnessing the Holley team's method, other scientists determined the structures of the remaining tRNA's. A few years later the method was modified to help track the sequence of nucleotides in various bacterial, plant, and human viruses. Modified further, the Holley team's approach is playing a role in determining the sequence of DNA's in today's chromosomal research. ■

New Kinks with Cotton...

To improve the wearability of the durable-press cotton they had developed in the 1950's, scientists ran abrasion tests and studied the results under the electron microscope. (PN-1922)

King Cotton was in trouble. With the cessation of World War II, cotton markets were being usurped by synthetics. The marketing war's opening round was the advent of rayon strong enough for use in tire cords. Soon tiremakers began switching from cotton to its lower priced competitor, dispossessing growers of an annual market for 1 million bales of cotton.

Another inroad into cotton markets followed the introduction of men's shirts made of synthetic fibers that needed little or no ironing. Concurrent-

ly, nylon was laying siege to markets for women's garments and for many household items that cotton had traditionally filled.

ARS chemists and engineers at the Southern Regional Research Center in New Orleans, along with colleagues in industry, launched a broad-based research campaign to close the gap. Before long, progress in research began to bolster cotton's competitive position.

A series of basic discoveries involving resins resulted in cotton fabrics that behaved like synthetics when washed and hung to dry, yet retained such desirable qualities as comfort and resistance to soiling. Work in laboratories was further accelerated at about this time when major shirtmakers raised their research budgets on learning that many people considered synthetic shirts to be wanting in comfort.

From this effort of the 1950's came the first wash-and-wear cotton shirts that required only touch-up ironing. Next came shirts, pants, and other clothing made from a new blend of 35 percent cotton with 65 percent synthetics. These garments had permanent creases and, after washing and either tumble- and drip-drying, required no ironing.

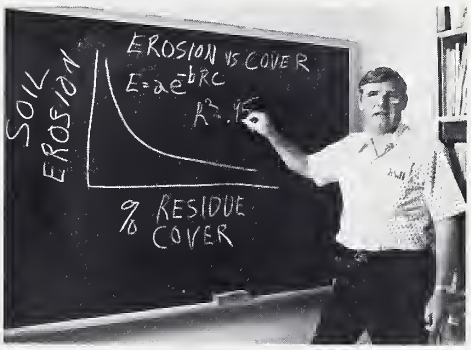
But the New Orleans scientists refused to settle for shirts, underwear, and sportswear limited to only 35 percent cotton. Contending that garments of all cotton were more durable than those made from the blend, they stepped up their efforts. They succeeded. Since 1965 consumers have been able to buy all-cotton shirts that are durable yet look newly pressed after repeated launderings and dryings.

The key to making cotton wash-and-wear—or durable press, as it is now called—is to treat it with a chemical solution which reacts with the long molecules that compose cotton fiber. The treatment "crosslinks" or ties the molecules together so that the fabric will dry smooth after laundering. Today durable-press textiles are providing an annual market for an estimated 2.5 million bales of cotton that otherwise would not be sold.

But durable-press cottons account for only a part of the New Orleans lab's total textile research program. Over the years researchers there have created a succession of processes and products. These include a host of new finishing and crosslinking agents to make fabrics last longer and resist wrinkling, soiling, and damage by bleaches; weather-resistant canvases for such varied products as tents, tarpaulins, and beach umbrellas; and flame-retardant fabrics for clothing for fire fighters and foundry workers, bed linens for hospitals and institutions, and linings for high-pressure chambers for nursing blue babies after surgery.

All these and many other research achievements have helped win markets for cotton. To the general public, however, the towering triumph in textile research undoubtedly is durable-press cotton. It is liberating the masses from countless hours of drudgery at the ironing board. ■

Saving a Fragile Resource...



At the National Soil Erosion Laboratory, W. Lafayette, Ind., soil scientist William C. Moldenhauer continues to refine factors to improve the Universal Soil Loss Equation.

Pelting rain and rushing snowmelt had long washed soil from the steep potato field. Uprooted potatoes lay scattered about after downpours. Fresh deposits of soil clogged road ditches bordering the field.

The farmer and local soil conservationist were walking the field to plan a remedy. When they stopped, the conservationist held up a little workbook and said, "Here's a simple tool that'll pinpoint some practical solutions to your erosion problems. It's the Universal Soil Loss Equation—USLE for short."

The conservationist explained that after plugging in six factors, the USLE would predict the long-term yearly erosion rate for the field under specified cropping and management conditions. The planning goal was to reduce erosion to a level that permitted the field's productivity to be sustained indefinitely—in this case, 3 tons per acre annually.

"Nature itself largely controls three of the six equation factors," the conservationist said. "Those are rainfall energy and intensity, erodibility of the particular soil, and steepness of the slope. Length of slope can be partially modified. But every farmer fully controls two factors, cover crop and soil management practices, and erosion control practices."

Explanations over, the conservationist got to work determining soil type, percent of slope, and length of slope. Then he referred to tables in the workbook and punched a calculator.

"Your continuous potato rotation, planted up and down hill, loses almost 15 tons of soil per acre every year," he concluded. "Now let's check some alternatives."

In quick order, the conservationist applied USLE to gauging soil losses under several practices. He suggested growing a rotation of potatoes-oats-hay and installing contour strips. That alternative would hold soil losses well below tolerable levels. The farmer vetoed it, however, because it would reduce his income by cutting into his potato cash crop acreage.

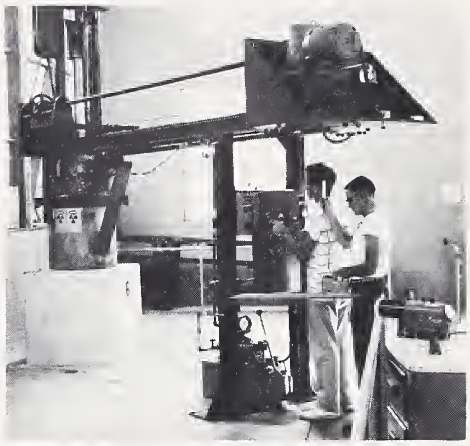
The solution ultimately selected was to reduce the slope length by installing a diversion ditch 400 feet below the field's crest to control runoff. Next, the diversion would be combined with a potato-oats rotation grown across the slope. Then, by incorporating conservation tillage practices that hold soil

disturbance to a minimum and leave most crop residues on the field, the farmer could keep soil losses under 2 tons per acre.

Although the conservationist applied USLE in minutes to save the potato grower's soil, the equation rests on over half a century of research in many States. Similar equations were put to use in the Corn Belt and the Northeast during the 1940's, but the USLE is the first to be applicable nationally. Its broad-based usefulness stems from the painstaking analysis of precipitation data from over 65,000 individual rainstorms and runoff and soil loss data from 49 field plots.

Major credit for developing USLE—which was released in 1960—belongs to ARS agricultural engineer Dwight L. Smith and research statistician Walter H. Wischmeir. In recent years the equation has been improved and refined by other ARS researchers, particularly soil scientist William C. Moldenhauer and hydrologic engineer George R. Foster. Today, USLE is a major weapon in combatting the annual loss of 2 billion tons of soil that wash from the Nation's croplands. ■

Duping a Pest Into Annihilation...



Wild, fertile female screwworms laid nonhatching eggs when they mated with male screwworms sterilized by being irradiated in this machine. The sterile-male technique eventually eradicated this destructive pest from the United States. (PN-7077)

The tired rancher dismounted, caught another calf, and smeared medication on its bloody navel—evidence of flesh being eaten by screwworm fly maggots.

It was 1960 in Texas and the screwworm was wreaking havoc by laying eggs in open wounds which, if not treated, could kill a young calf in 10 days. Some years the screwworms claimed 10 percent and more of the rancher's calf crop. Losses were $100 million per year in Texas alone.

In 1965, a happier scene prevailed on Texas rangelands. Science had duped the screwworm fly into breeding itself out of existence.

Control of the screwworm had its roots in a revolutionary idea conceived years earlier by ARS entomologist Edward F. Knipling, who thought insects could be used for their own self-destruction. He proposed to rear insects in huge quantities, sterilize them sexually with radiation, and then release them from aircraft into infested areas to breed with normal insects. Such matings would produce no offspring, so that if enough sterile insects were released the species would be annihilated.

Knipling's first chance to test his theory against screwworms came in 1954 on the island of Curaçao off Venezuela. He chose the screwworm as the target species because of its monogamous breeding habits. In 6 months Knipling's new method wiped out the small island's screwworm population.

Success of the sterility principle, as the new method was called, brought a clamor for similar help from Florida cattle producers. The USDA designed a "fly factory" in Sebring that could rear 50 million flies a week at peak capacity. When the campaign got into full swing, 5-day-old pupae were sexually sterilized by exposure to radioactive cobalt-60, packaged 400 to a box, and dropped over infested areas from small airplanes. In only a year and a half, the pest was eradicated.

The Florida effort was a prelude to the large-scale campaign that was to unfold in Texas and the Southwest. A "fly factory" was housed at an abandoned Air Force base near Mission, Tex. It reared over 100 million flies a week—an effort that required nearly 60

USDA Research Achievements Before 1953

Dextran...a substitute or extender for blood plasma that was developed in time to help save the lives of U.S. servicemen fighting in Korea.

Penicillin...a method was devised to mass-produce this antibiotic for medical use in World War II by scientists at the Northern Regional Research Center in Peoria, Ill.

Aerosol container...originally designed by two researchers at the Beltsville Agricultural Research Center as an aerosol bomb for the dispersal of pesticides.

Concentrated orange juice...a product jointly developed by ARS and the Florida Citrus Commission that made possible a year-round source of vitamin C for consumers.

Beltsville Small White Turkey...geneticists bred this compact bird to meet the changing needs of smaller families.

Vedalia beetle...the Nation's first successfully introduced biological control agent; it curbed a scale insect that was threatening California citrus groves.

tons of ground meat, 6,000 gallons of blood, and 17,000 gallons of water. Total costs for the 3-year campaign were $12.5 million.

By the end of 1964, the screwworm was eradicated from Texas. It was later eradicated from small areas of Arizona and California that were not included in the original program, thus making the U.S. screwworm-free.

Mexico provided excellent cooperation during the campaign, permitting U.S. airplanes to drop sterile flies over its territory and thus establish a barrier zone that prevented the flies from coming north. Now a joint U.S.-Mexico campaign is underway to eradicate the screwworm in Mexico, from Texas to the isthmus of Tehuantepec.

Over the years, Knipling's sterility principle has also been pressed into service against such other formidable agricultural foes as the Mediterranean fruit fly, oriental fruit fly, and pink bollworm. ■

To Custom Tailor Plants...

Plant physiologist Harry A. Borthwick was one of the pioneers in photoperiodism research that led to later breakthroughs in plant growth regulators. (ST-3105-6)

A new frontier in agricultural research is revolutionizing the production of crops. Scientists who work at the level of cells and molecules are harnessing natural substances called bioregulators to govern plant growth and development.

Pioneer work in this field, which began in 1918, showed that by adjusting the amount of daylight a plant receives, scientists could control blooming and seed formation. The phenomenon was discovered in classic photoperiodism studies by USDA scientists Wightman G. Garner and Harry A. Allard who conducted research on tobacco. Results of their work have long helped florists make chrysanthemums, pionsettias, and other potted plants bloom at any season by exposing them to the correct day length. Plant breeders also controlled day length to cause simultaneous flowering of plants they wished to cross-pollinate.

In subsequent research at the Beltsville Agricultural Research Center, Harry A. Borthwick and Sterling B. Hendricks kept probing the underlying mystery of photoperiodism. They learned that a hidden substance in plants triggers all aspects of their growth, from seed germination to flowering and fruiting. Several years later the substance was identified as a light-sensitive pigment and named phytochrome. Since phytochrome can be made active or inactive, depending upon the wave length of the light it receives, man can switch plant growth on or off, as desired. The ground-breaking work of these four ARS scientists foreshadowed an era of custom-tailored plants to meet specific needs.

Over the years the scientific community has developed various bioregulators for today's agriculture. For example, orange and apple orchardists spray their trees with abscisins to loosen fruit and thus expedite mechanical harvesting. A chemical inhibitor called mepiquat boosts cotton yields by suppressing the growth of excess leaves and producing more fluffy bolls instead. Kinetin and ethylene help keep fruits and vegetables fresh after harvest. Auxins, depending on the type, can kill weeds, promote rooting of cuttings, or serve in herbicides to either retard or accelerate growth.

ARS scientists are still making significant contributions to knowledge about bioregulators. In basic biosynthetic research, for example, plant physiologist Morris Lieberman discovered that the amino acid methionine is a precursor for ethylene, the widely used postharvest agent. Plant physiologist John Mitchell found in pollen a new class of growth regulators that he called brassins. Now synthesized and named brassinosteroids, they are known to hasten crop maturity. Someday they may enable farmers to squeeze another crop into a continuous rotation, practice double cropping, or extend the range of less hardy crops into colder regions.

Looking toward the future, such bioregulators as the brassinosteroids may help increase a plant's uptake of soil nutrients to lessen dependence on costly fertilizers. Other chemicals may impart salt tolerance to crops that are to be grown on briny coastal soils. These new chemical allies of agriculture will enhance food quality and increase the land's productivity. ■

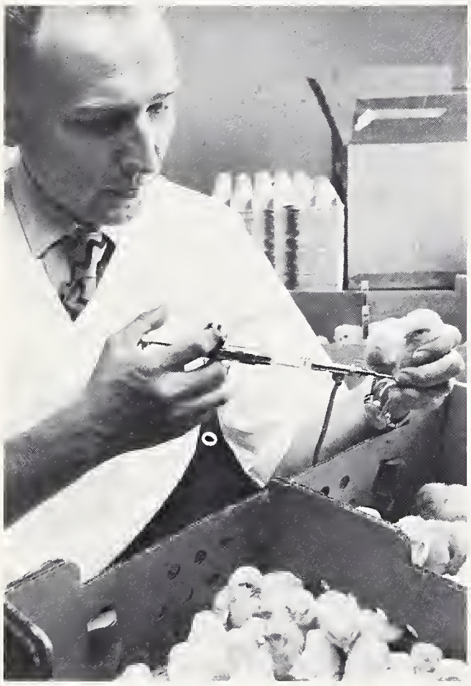
Vaccines to the Rescue...

Advances in molecular biology have paid off in vaccines to curb two diseases that can ravage livestock and poultry. One of the vaccines protects against foot-and-mouth disease (FMD), an explosively contagious scourge of cattle, sheep, hogs, and goats. The other vaccine protects against Marek's disease, which caused the poultry industry its heaviest losses of broilers and eggs.

Foot-and-mouth disease outbreaks have occurred several times in the United States, the last time being in 1929. Each outbreak brought somber scenes of eradication based upon the

costly strategy of shooting and burying all infected and exposed animals. Subsequently, the United States cooperated with Mexico in eradicating two major outbreaks there. But North America's livestock industry can never relax its vigilance. The FMD virus lurks in many herds around the world, making accidental introduction a constant threat.

The expectation of someday con-



Veterinarian Graham Purchase inoculates 1-day-old chicks with Marek's disease vaccine. Purchase was a member of the team that developed the vaccine. (0673A1226-25)

quering FMD was raised in 1975 by news from the Plum Island Animal Disease Center—an isolated, maximum security research facility off the coast of Long Island, N.Y. ARS researchers there had discovered that injection of a protein derived from a portion of the coating of FMD virus and called VP_3, confers immunity to the disease. However, methods then available for mass-producing a VP_3 vaccine were not economically feasible.

In 1980 the Plum Island scientists turned to another route to develop a safe and inexpensive vaccine—recombinant DNA technology. The USDA team was led by biochemist Howard L. Bachrach and collaborated with scientists from Genentech, a private research company. The researchers inserted a bioengineered plasmid containing the gene for VP_3 into *Escherichia coli* bacteria. As these bacteria grew, they obeyed orders from the guest DNA and mass-produced the desired VP_3 proteins. In 1981 the scientists reached their goal: a VP_3 vaccine was produced that did not make either infectious virus or infectious RNA.

The Plum Island research achievement now enables the U.S. to produce and hold a ready supply of FMD vaccine for emergency use. Equally important, the vaccine can be stored indefinitely without refrigeration, a boon to countries that rely on vaccination to control FMD.

Victory over Marek's disease was gained by an internationally known team of scientists, led by Ben Burmeister (now retired), that first conceived and then carried out a comprehensive research program composed of a number of well-defined steps. Each of the steps, conducted at the ARS Regional Poultry Research Laboratory, East Lansing, Mich., served as a stepping stone toward the single goal of developing a successful vaccine.

Poultry producers urgently needed a vaccine to control diseases of the avian leukosis complex: Marek's and the closely related lymphoid leukosis, both of which are cancer-like diseases of lymphoid cells. Three years before the advent of this vaccine, these diseases were responsible for over 48 percent of all poultry condemnations at processing plants, and half the death losses in flocks. Moreover, infected laying flocks were producing fewer eggs.

The economics of poultry production improved dramatically after the vaccine hit the market in 1971. Death losses declined. Condemnations dropped by more than 5 percent at processing plants. Egg production of vaccinated birds, compared with those not vaccinated, climbed 3 percent. For consumers, higher egg production and reduced death losses in laying flocks restricted rises in egg prices.

Another economic advantage made possible by the vaccine is that U.S. egg requirements can now be met with 9 million fewer layers. Using the vaccine in laying flocks also releases about 100,000 acres for production of crops other than poultry feed.

In developing the vaccine, the first and most important advance was the positive identification and isolation, both at East Lansing and Houghton, England, of a herpes virus as the cause of Marek's disease.

A significant second step was the isolation of a turkey herpes virus which was nonpathogenic. This virus was related to Marek's disease virus, and was capable of protecting chickens against Marek's disease.

Then followed the other research steps, including producing reagents,

Returns from the Research Dollar

A return on the dollars invested in scientific research can often be spectacular.

In 1971, the first year the ARS-developed vaccine for Marek's disease was made available for national use, benefits from the vaccine amounted to $30 million. This meant that in 1 year the benefits had paid back nearly 100 percent of the total 10-year investment of $32 million.

By 1974, the first year of full adoption of the vaccine by the poultry industry, gross benefits had climbed to $628 million. Since then, net benefits stemming from use of the vaccine are estimated to total $168 million annually, and in 1983 total benefits are estimated to have reached the $2 billion mark.

assaying antigens and antibodies, developing and testing and evaluating the vaccine.

The research which culminated in a vaccine against Marek's disease not only bolstered the poultry industry, it also presents guidelines for scientists working on human cancer vaccines. ■

Germplasm for the Green Revolution...

The genes that sparked the Green Revolution came from unprepossessing wheat plants relegated to the ranks of agronomic curiosities. But their short, stiff straw and heavy seed heads caught the eye of ARS agronomist S. Cecil Salmon who was with Gen. Douglas MacArthur's headquarters in 1946 helping assess Japan's postwar agricultural problems. Salmon acquired seeds of 16 different strains—including one named Norin No. 10—for the World Small Grain Collection in Beltsville, Md.

Within a year, the Collection processed and distributed the seeds to various U.S. wheat breeders. Some went to ARS-Washington State University breeders in Pullman. The Pullman team, led by ARS plant breeder Orville Vogel, analyzed the seeds' initial progeny for strengths and weaknesses. Over the next 13 years the scientists made many hybrid crosses and selections. One of the wheat varieties that came out of these efforts was the famed short-strawed Gaines.

While hybridization was underway, Norman E. Borlaug of the International Maize and Wheat Research Centre, Mexico, visited Pullman and was impressed with the short-stalked wheat's potential. The group shared germplasm with Borlaug who, in turn, crossed it with Mexico's best wheats.

In 1963 Borlaug responded to an urgent request from the government of India to tour its major wheat-growing regions and provide breeders with lines containing Norin No. 10 dwarfing genes. The tall native wheats had encountered an insurmountable yield barrier. When heavily fertilized with nitrogen, they grew too high, became top-heavy, and lodged.

Agronomist and geneticist Orville Vogel, a leader in the Green Revolution, is still active in wheat breeding after a long career with ARS. (0983X1277-33)

Borlaug's semidwarf wheats enabled India to finally launch its Green Revolution. The combination of new genes, fertilizer, and irrigation spurred wheat production from 12 million metric tons in 1965 to over 20 million in 1970 and over 37 million last year. Since the new wheats were broadly adapted, Green Revolutions also took hold in countries sharing similar latitudes, such as Pakistan, Turkey, and Afghanistan. For his contributions, Borlaug was awarded the Nobel Prize.

Arid regions of India also benefitted from a Green Revolution, one based on hybrid pearl millets. But an obstacle to hybridization had to be overcome first because many grasses, including millets, self-pollinate. ARS geneticist Glenn Burton altered pearl millet's cytoplasm to create the cytoplasmic male-sterile plants that made hybrids possible. In 1961 Burton sent male-sterile millet seeds to India for its breeding programs. By 1965 the Indian scientists developed a new hybrid that outyielded native varieties by 88 percent. In that year, India produced 3.5 million tons of millet. Just 5 years later, millet production climbed to 8 million tons. That gain in yield accounted for 20 percent of the extra food production in India's Green Revolution.

Plant breeders rely on the collection and preservation of still-extant germplasm. A major effort is underway to save from extinction not only the seeds of plants now cultivated but also their wild relatives with rich and irreplaceable genetic qualities—from resistance to disease and drought to higher yields. A wide variety of genetic material is essential if breeders are to improve and perpetuate the world's crops.

Two internationally known facilities are maintained by ARS to help foster genetic diversity. The World Small Grain Collection, which can be traced to informal origins in the 1870's, serves as a "working" collection. It collects, maintains, distributes, and evaluates germplasm to meet the ongoing needs of plant breeders everywhere. At present, the Collection maintains some 102,000 strains of wheat, barley, oats, rice, rye, and triticale.

On the other hand, the National Seed Storage Laboratory (NSSL), Fort Collins, Colo., is a "base" collection. It maintains, mostly in cold-storage rooms, over 200,000 separate collections of seed and vegetative stock. Some collections were obtained by expeditions to remote lands. Although the NSSL's germplasm may duplicate that in working collections, it releases material only when it is not available elsewhere. Its prime mission is to perpetually safeguard germplasm, an ultimate gene bank for the plant breeders working to help feed the world's burgeoning population.— *(By Russell P. Kaniuka, Beltsville, Md.)* ■

Weevil Attractant Unites Insects

The come-hither scent of a male maize weevil provides the insect with plenty of company. Researchers have found that its scent, or aggregation pheromone, calls forth rice weevils, granary weevils, other male maize weevils, mated female weevils, and especially, virgin female maize weevils.

The discovery provides insights into the feeding and mating habits of the insects that may help ARS and University of Wisconsin scientists toward their goal: Curbing losses of corn and other cereal grains while minimizing the use of insecticides.

"Future isolation, identification, synthesis, and commercial development of the aggregation pheromone could advance integrated pest management schemes against the grain weevils," says ARS entomologist Wendell E. Burkholder, Madison, Wis.

The grain weevils account for hundreds of millions of dollars in losses annually to inventories of cereal grains.

In the Southern United States, maize weevils are notorious for reducing corn, wheat, rice, and sorghum to dry powder and hulls. Besides infesting granaries, the adults fly from the granaries to fields to start infestations before harvest.

Maize weevils often hollow an entire wheat kernel before feeding on other untouched kernels. One weevil chewing alone through a seed coat would have to expend a great deal of time and energy, says Burkholder. By attracting other weevils to the scene, a hungry male can get help for the task.

Graduate student Catherine Walgenbach and Burkholder extracted pheromones from paper discs taken from vials that had held insects and cracked wheat kernels for 10 days. Then they applied precise amounts of the extract to paper discs in a special chamber which trapped the attracted insects.

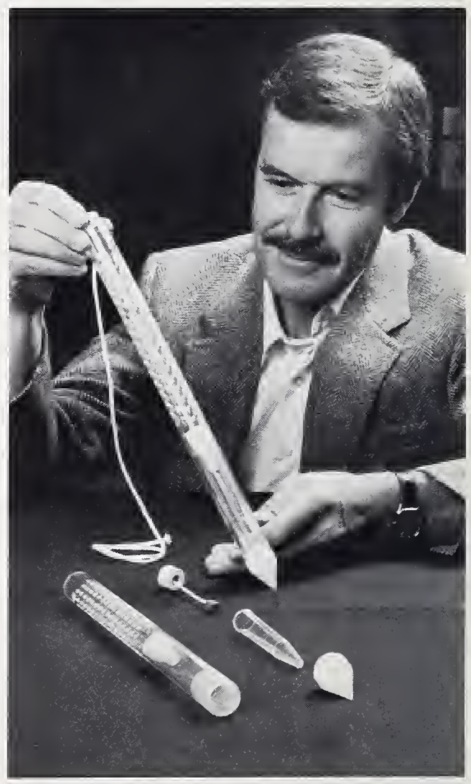
The researchers found that the extract attracted virgin female maize weevils more than it attracted their mated sisters. It attracted virgin females, virgin males, and mated males about equally.

"We suspect that release of the pheromone evolved as a survival

A high-magnification video recording system enables research assistant Catherine Walgenbach to monitor the mating behavior of maize weevils. Data from these studies may improve integrated pest management strategies using insect pheromones. (0983X1309-3)

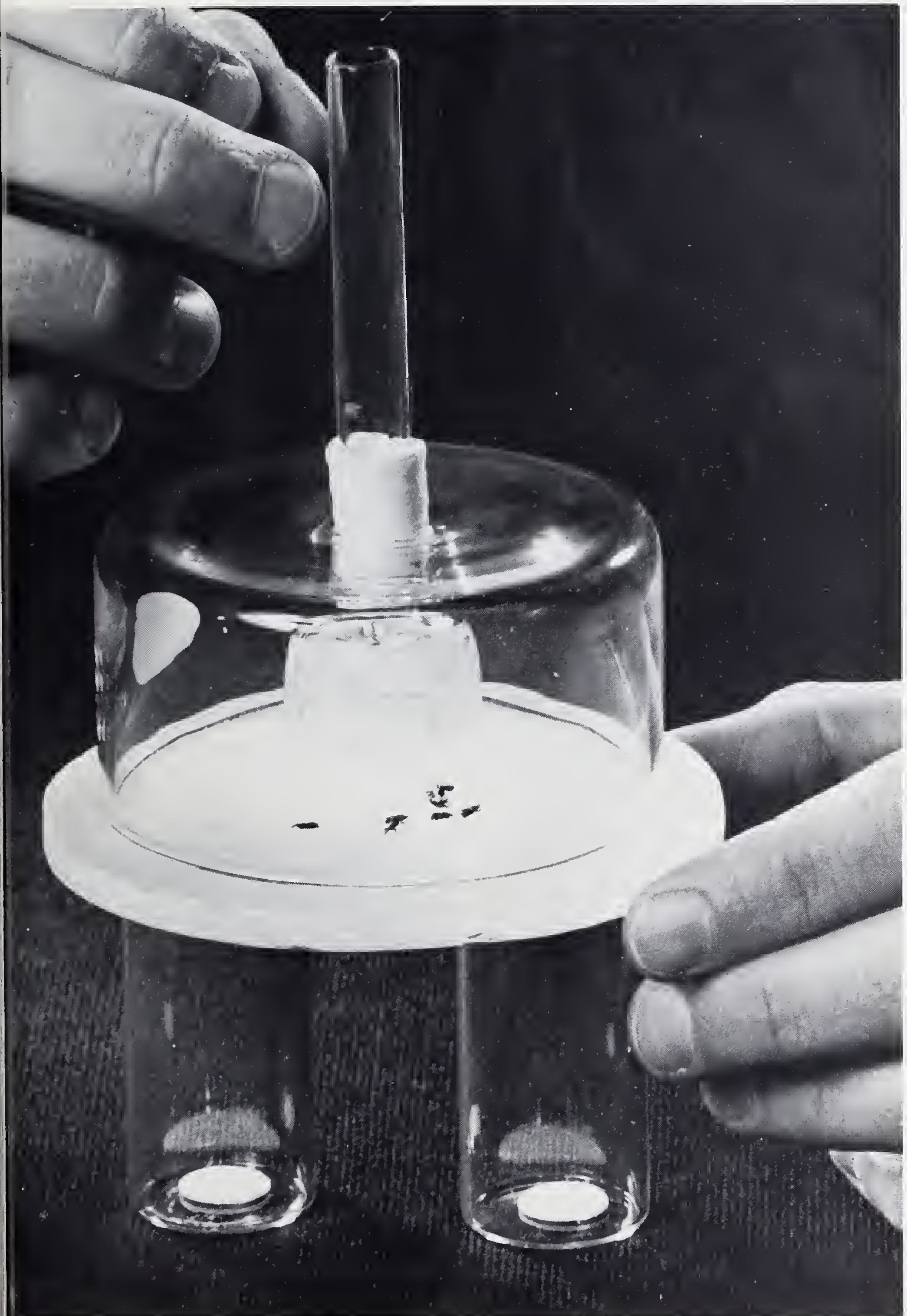
mechanism for the species, bringing insects together to engage in feeding and mating at optimum locations," says Burkholder.

The research also sheds light on the weevils' evolution. Burkholder and his colleagues found that rice weevil extracts attracted female granary weevils, but maize weevil extracts attracted both male and female granary weevils. Neither maize nor rice weevils were greatly attracted to granary weevil extracts. This indicates a close relationship between the maize and rice weevils and a more distant relationship of these insects to the granary weevil.



Wendell E. Burkholder is located at the Dept. of Entomology, University of Wisconsin, Madison, Wis. 53706.—(By Ben Hardin, Peoria, Ill.) ■

Reducing Fruit Moisture by Osmosis



Far left: An infestation of maize weevils turns stored kernels of wheat into hollow shells and a powdery residue. (0983X1311-29A)

Left: ARS entomologist Wendell E. Burkholder displays his newly designed trap for weevils and other insects in stored grain. The device has been successful, especially when baited with food or pheromones, in trapping weevils in farm and commercial grain storage facilities and on grain-carrying river barges. (0983X308-34A)

Above: To test the luring strength of the maize weevil attractant, weevils get to choose between two vials—one containing a plain grain extract and the other a grain extract supplemented by the male maize weevil pheromone. (0983X308-4A)

Although most strawberry-eaters do not think of it at the time, when they sprinkle sugar on strawberries, osmosis begins: water oozes out of the fruit and makes a syrup with the sugar.

Based on the same principle, a new technique—osmotic concentration—has been found to halve the weight and consequently the volume of apples, peaches, and apricots without seriously hurting the fruits' flavor, color, or texture.

"Osmotic concentration is one of the most efficient ways to remove moisture from fruits because water doesn't have to go through a phase change—water to steam—as it leaves the product," says ARS chemist Harold R. Bolin, Western Regional Research Center, Berkeley, Calif.

Currently used techniques for moisture reduction, such as hot-air drying, either consume huge quantities of energy or can be used only for liquid end products such as orange juice or tomato puree. Bolin calculates that only 25 percent as much energy should be required by the osmotic-concentration procedure for removing water as compared to hot-air drying.

In laboratory experiments, Bolin, agricultural engineer Charles C. Huxsoll, and food technologists Rogernald Jackson and Keng C. Ng processed apples, peaches, and apricots by immersing about 1 1/3 pounds of cut-up fresh fruit at a time into a container holding about 5 pounds of 70-percent concentrated sucrose sugar syrup. After 6 hours at about 160°F, internal moisture from the fruit had migrated to the syrup, diluting it to a 60-percent concentrate.

"We were able to reconcentrate the diluted syrup back to 70-percent concentration and reuse it five times without affecting fruit flavor or appearance, even though the osmotic syrup itself did darken," Bolin says. When used in commercial operations, it should be possible to reconcentrate the syrups more than five times because fresh syrup could be added periodically.

Harold R. Bolin, Charles C. Huxsoll, Rogernald Jackson, and Keng C. Ng are located at the Western Regional Research Center, 800 Buchanan St., Berkeley, Calif. 94710.—(By Dennis Senft, Oakland, Calif.) ■

No News is Good News for Beekeepers

There are no parasitic mites of honey bees in U.S. apiaries, according to a recently completed national survey and sample inspection of colonies.

This good news from ARS scientists at the Bioenvironmental Bee Laboratory in Beltsville, Md., should be a relief to the estimated 210,000 U.S. beekeepers. The $25 million-per-year industry in package sales of bees and queens would be threatened by the presence of mites.

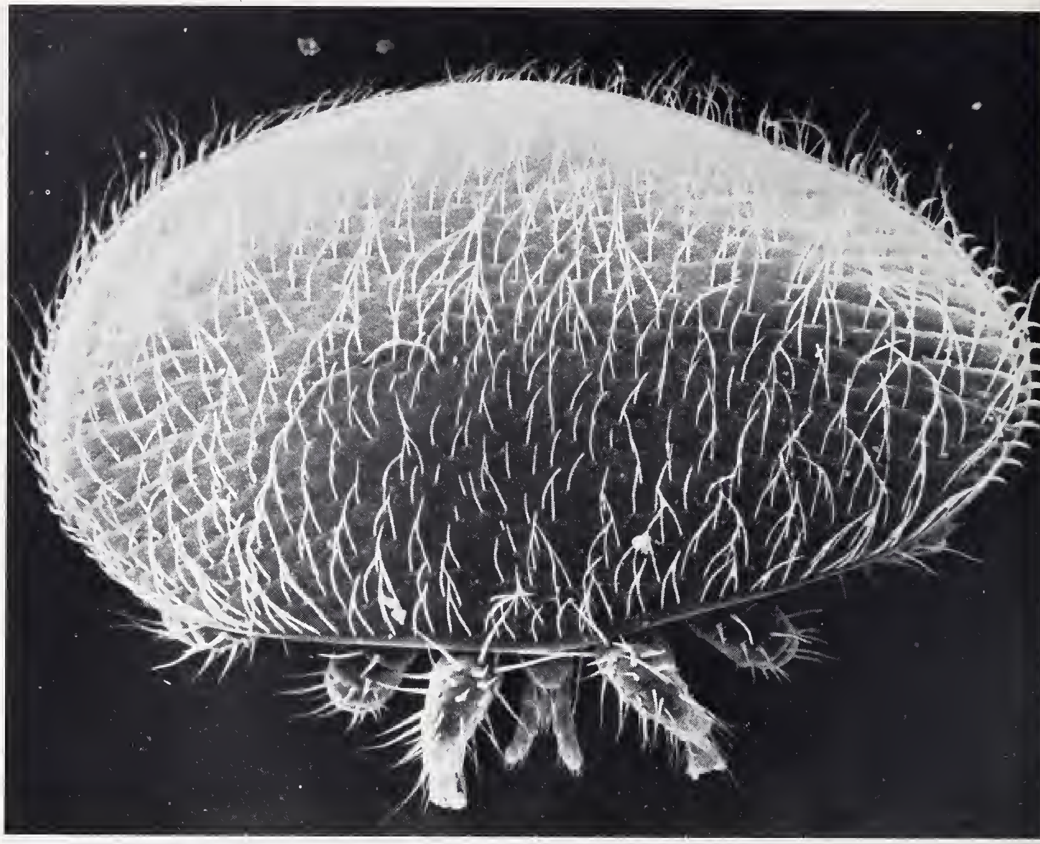
The United States is a principal producer and exporter of honey bees, and one of few major beekeeping nations to be free of two highly destructive species of honey bee mites, *Varroa jacobsoni* and *Acarapis woodi*.

In mid-1981 suspicions ran high, according to Bee Laboratory chief Hachiro Shimanuki, that parasitic mites had for the first time infested the Nation's apiaries. There was a false report in 1980 of *V. jacobsoni* in a Maryland bee colony. Also, *A. woodi* was recently found in Mexico, 150 miles from the Texas border.

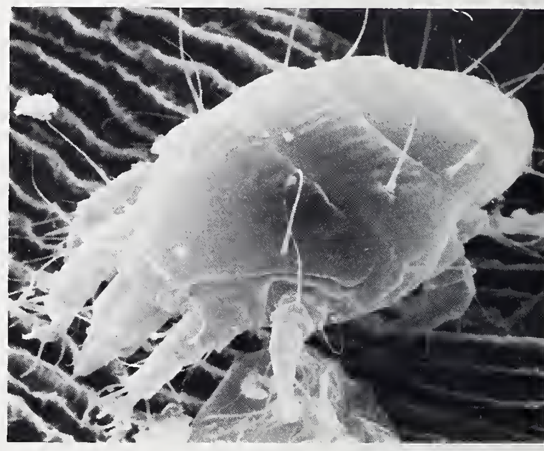
In 1982, ARS and USDA's Animal and Plant Health Inspection Service (APHIS) provided State departments of agriculture with containers for sending in sample bees and instructions for making field collections. More than 200,000 bees from 44 States, Puerto Rico, and major beekeeping areas of Canada were mailed in to the Beltsville lab for examination.

According to Shimanuki, U.S. beekeepers enjoy an excellent reputation abroad as reliable sources of healthy bees and diverse genetic honey bee stock. Beekeepers in Canada, for example, import over $6 million in U.S. honey bees each year. Importing bees each spring tends to be less expensive for Canadian beekeepers than keeping colonies overwinter, Shimanuki explains.

"In order to prevent quarantines of U.S. bees by Canada or other nations, colonies must be periodically monitored by trained professionals. The parasites are very tiny and difficult for beekeepers to detect. Even the symptoms—deformed bees, decreased stamina and longevity, impaired flight—develop only after the parasitic mites have been with a colony for months," says Shimanuki.



Neither of two destructive parasites—the *Varroa jacobsoni* mite (above) and the *Acarapis woodi* mite (below)—is present in American or Canadian honey bee colonies, according to a recent thorough survey. (Scanning electron micrographs by William E. Styer of the Ohio Agricultural Research and Development Center.) (PN-7070, PN-7071)



It is widely feared by beekeepers that if bee mites entered the United States, they would spread quickly, due to the mobility of the bee industry. To provide crop pollinating services, beekeepers move colonies from State to State. Such shipments are largely responsible for the spread of bee mites around the world.

V. jacobsoni, an external bee parasite, affects both adult bees and their brood. The mites deform and often kill the brood. The parasites measure 0.04 to 0.08 inches (1 to 2 mm) in width.

A. woodi is microscopic in size—approximately 0.036 inch (0.09 mm). It lives and breeds inside honey bees' breathing tubes.

Although the survey as designed by APHIS has been completed, Shimanuki says his laboratory will continue to accept bee samples for mite inspection. Do not send samples directly to Beltsville, however. Contact your State agriculture department for procedures.

Hachiro Shimanuki is located at the Bioenvironmental Bee Laboratory, Bldg. 476, Beltsville Agricultural Research Center-East, Beltsville, Md. 20705.—(By Stephen Berberich, Beltsville, Md.) ■

Turnips for Forage

Conservation tillage is bringing turnips into the limelight as a forage crop, along with other members of the Brassica family such as rape, kale, and rutabagas.

The use of these high-yielding, nutritious, and highly digestible crops as a means to improve pastureland efficiency has been under study by ARS research agronomist Gerald A. Jung at the U.S. Pasture Research Laboratory, University Park, Pa.

Jung and research entomologist Robert A. Byers, working with Lynn D. Hoffman of The Pennsylvania State University, have successfully grown Brassica crops in the hill lands of Pennsylvania. They have also been grown in West Virginia, Ohio, Illinois, Wisconsin, New York, Florida, Louisiana, and North Carolina. Central Washington and northern Oregon show good potential as additional growing sites, according to Jung.

Under conservation tillage, turnips are planted directly into the sod of an existing pasture. They can be grazed in all kinds of weather, since the sod remaining between the turnip rows minimizes soil compaction. Also, turnips retain their nutritional value long after cool-season grasses have reached their peak. "Animals can graze until December turnips that were seeded in August," Jung says.

Rape and kale leaves contain up to 25 percent protein, and the stems contain about 10 percent. Turnips and rutabagas have about 15 percent protein in the leaves, and up to about 8 percent protein in the roots. The mineral content of Brassica species, except possibly for copper, is higher than most grasses, and standard laboratory tests indicate these forages are 15 to 25 percent more digestible than good alfalfa.

Brassica crops are also highly productive: turnips planted in August produce in 90 days the equivalent energy to 115 bushels of corn.

Further research by David Gustine at the U.S. Regional Pasture Research Laboratory will determine if goiter-forming substances are a problem in Brassica crops.

Gerald A. Jung is located at the U.S. Regional Pasture Research Laboratory, Curtin Rd., University Park, Pa. 16802—(By Ellen Mika, Beltsville, Md.) ■

Late to Feed, Early to Calve

ARS studies suggest that feeding heifers only at night during the last week before calving increases the likelihood of daytime births—making it much easier to spot calving problems in time. (GPA-18-13-22A)

Feeding pregnant heifers in the evening, rather than in the morning as is commonly done, resulted in 17 percent more daytime births.

Cattle producers must sometimes assist heifers and cows during calving if they experience calving difficulties, and it is much easier for producers to spot problems during daylight. If the dam is not given help, her life and that of the calf could be endangered.

Scientists at the Fort Keogh Livestock and Range Research Laboratory, Miles City, Mont., started studies with 42 heifers confined to a feedlot during the entire calving season. The heifers were fed all the corn silage they would eat in 8 to 10 hours plus 2 pounds of ground barley. Starting 1 week before calving began, scientists fed half the heifers between 8 a.m. and 9 a.m. daily and the other half between 8 p.m. and 9 p.m. daily. Seventeen percent more of the evening-fed heifers calved during daylight than the morning-fed heifers.

The scientists expanded their study the next 3 years to include more than 800 heifers.

"Both the morning-fed group and the evening-fed group received 20 to 25 pounds of alfalfa hay and 3 pounds of pelleted barley. Again, 14 to 17 percent more of the evening-fed heifers calved during daylight," says animal physiologist Robert A. Bellows.

Canadian research, a summary by Iowa State University, and observations by beef producers and veterinarians have also indicated an advantage for evening feeding.

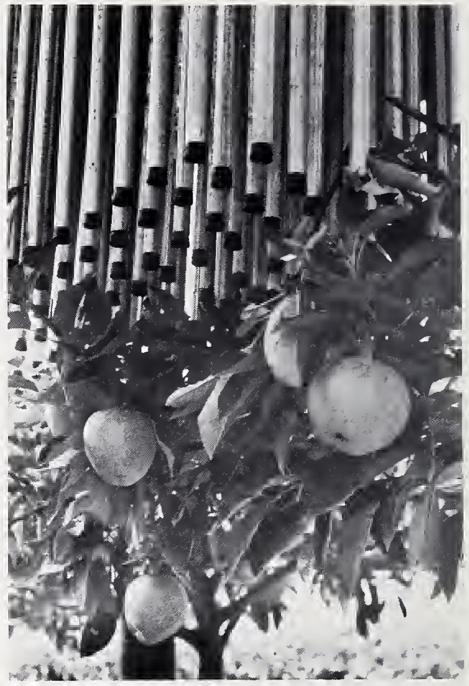
"These findings are preliminary, but for now, I suggest producers try feeding in the evening. But they definitely shouldn't eliminate their night calving crews since we have not totally eliminated calving at night," says Bellows.

All the breeds present in the laboratory's holdings were included in the study, and no differences among breeds were found in the results.

Robert A. Bellows is located at the Fort Keogh Livestock and Range Research Laboratory, Rt. 1, Box 2021, Miles City, Mont. 59301.—(By Dennis Senft, Oakland, Calif.) ■

Metal Fingers Can Be Gentle Fruit Pickers

The aluminum fingers of the ARS-designed rod press fruit remover are lowered through the limbs and foliage of trellised apple trees uniquely suited to this type of mechanized harvesting. (0983A1229-3)



Each aluminum rod is spring-loaded to slide back if it should encounter a branch—or, with peaches, a fruit not yet ripe enough to detach. (0983A1228-11A)

Fresh market fruit may someday be pushed from the tree by long aluminum fingers that harvest as gently as human hands. Before the metal-fingered device can be useful, however, the grower must have properly shaped trees, and that will probably require trellising.

Orchardists still turn to hand labor to pick fresh market apples and peaches even though there are a number of commercial mechanical harvesters that shake the tree and catch the falling fruit. A number of other devices designed to rake or rotate the fruit off the tree have not made it to the commercial stage.

The problem, according to ARS agricultural engineer Donald L. Peterson, is too much bruising, especially with apples. Vigorous shaking causes the clustered fruit to knock together before detaching. And falling fruit may bounce off a lower branch on the way to the catching surface. Apples, Peterson points out, are more prone to bruising than peaches because they are picked riper. However, because the peach crop ripens unevenly over a 2-week period, vigorous shaking causes some peaches to detach before they are ripe enough.

The solution? Gently push the fruit off a tree whose branches are all on the same level.

To do the job, Peterson designed a simple device that can be attached to a tractor or self-propelled machine and lowered through the fruiting branches. At the same time, his colleague at the Appalachian Fruit Research Station, horticulturist Stephen S. Miller, designs tree shapes compatible with mechanized harvesting.

The rod press fruit remover, as Peterson calls his invention, consists of an aluminum panel projecting closely spaced rods—the fruit pushers.

The aluminum rods have rubber tips to protect the tender fruit, and each rod is equipped with a spring tension release in case it comes to rest on a branch instead. After a certain pressure, the release allows the rod to slide back through the panel and thus prevent the limb from snapping. A padded catching surface beneath the branches collects the falling fruit.

The result of this careful engineering has proven equal to or better than good hand-harvesting in preliminary

tests, Peterson says. He and his colleagues harvest 80 to 90 percent Fancy-Extra Fancy apples and 88 percent No. 1 grade peaches with this equipment. Hand-harvesting yields anywhere from 60 to 90 percent fruit of this quality, depending on the experience of the picker.

Peterson says the rod press remover can be adapted to large or small fruit-growing enterprises by simply changing the size of the panel.

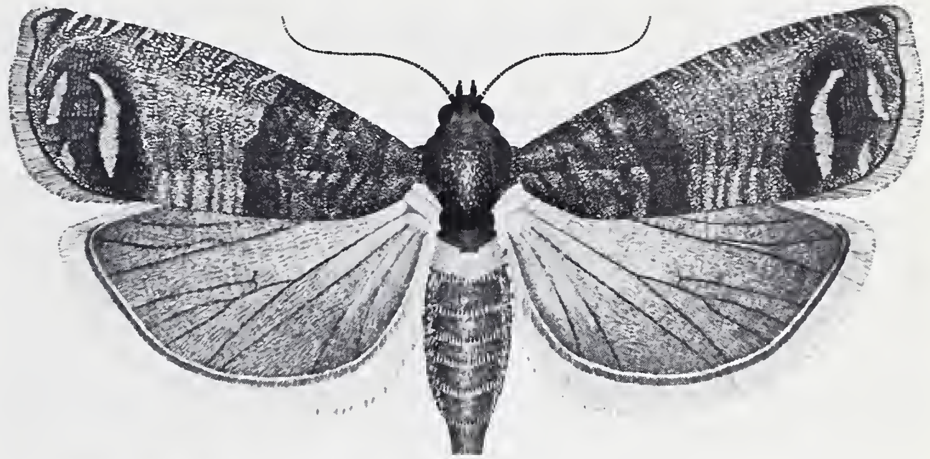
In his related research on compatible tree shapes, Miller has trained V-shaped peach trees by adapting an Australian type of trellis. Because these trees have only two scaffold limbs projecting from opposite sides of the tree, there are no limbs in the path of falling fruit.

For apples, Peterson and cooperators at West Virginia University are experimenting with a trellis developed in New Zealand. The trees are trained in a T-shape with the fruiting branches growing in a single horizontal tier supported by a post-and-wire system running down the row. Miller is also developing freestanding apple trees with compact fruiting canopies.

Trellised orchards have not caught on in the United States, says Peterson, because of the initial cost of setting them up. He predicts, however, that they may prove to be less costly and labor intensive to maintain in the long run because they lend themselves to mechanization. They also bear a harvestable crop sooner.

Miklos Faust, plant physiologist and chief of the ARS Fruit Laboratory, Beltsville, Md., says that very high-density orchards of dwarf trees—700 to 1,000 trees per acre—have become more popular in Europe because of the scarcity of land. (Dwarf trees require trellising because of their shallow root systems.) Land costs in Europe are six to seven times higher than in the United States, he explains, making the initial outlay for a trellised orchard only one-third to one-half of land value. In the United States, however, trellising costs may run two to three times more than the land.

Donald L. Peterson is located at the Appalachian Fruit Research Station, Rt. 2, Box 45, Kearneysville, W. Va. 25430—(By Judy McBride, Beltsville, Md.) ■



The adult female codling moth, *Cydia pomonella* (L.), has a wingspan of about 4/5 in (20 mm). (From *Tortricid Fauna of Apple in New York,* New York State Agricultural Experiment Station, © Cornell University, 1971.) (PN-7075)

Gamma Rays Control Codling Moths

Gamma rays are being tested as a means of controlling codling moths, *Cydia pomonella (L.)*, under fruit storage conditions where fumigation will not work.

Preliminary tests conducted by ARS entomologists Harold R. Moffitt and Arthur K. Burditt, Yakima, Wash., have shown that gamma radiation kills all exposed codling moth larvae, including larvae in the diapausal or dormant stage.

Fumigation with methyl bromide, a treatment developed by Moffitt and his coworkers in 1978, is 100 percent successful in killing codling moths in sweet cherries, which are harvested in spring. However, the treatment has limitations when applied to apples and pears because they are harvested in the fall and the codling moths are frequently in diapause, a form of hibernation. Fumigation has little effect on a diapausing insect because its respiration rate is very low.

Although irradiating food products to control insects is not new, the question of its safety always arises. Burditt, who has done extensive work on irradiating quarantined fruit for fruit flies in Hawaii, says "there's no carryover of radiation in the fruit and minimal effect on the fruit. Gamma irradiation of food is considered safe for human consumption at doses of 1 kilogray (10 kilorads) or less."

Harold R. Moffitt and Arthur K. Burditt are located at the Yakima Agricultural Research Laboratory, 3706 W. Nob Hill Blvd., Yakima, Wash. 98902.—(By Lynn Yarris, Oakland, Calif.) ■

Wheat Tolerance to Wheat Streak Mosaic

Variety tests of hard red spring wheats for tolerance to wheat streak mosaic virus showed Prodax, Coteau, Butte, and James performed best.

The disease, caused by a virus and spread by the wheat curl mite, is a serious problem in the central and northern Wheat Belt. It produced 100 percent losses in some fields in North Dakota and South Dakota in 1978, according to Roland G. Timian, ARS plant pathologist at North Dakota State University, Fargo.

The disease also occurs on barley, corn, rye, oats, and many grasses, as well as spring wheat.

In 2-year inoculation tests on Olaf, Coteau, Sinton, James, Butte, and Prodax, the best yield averages were for Prodax at 25 bu per acre, Coteau at 23.5 bu, and James at 19 bu.

In 1-year tests on Waldron, Eureka, Len, Solar, Benito, and Pro Brand 711, the latter gave the best yield averages at 24 bu per acre, followed by Benito at 22 bu, and Solar at 17 bu.

"Olaf and Waldron, two of the more widely grown spring wheat cultivars in western North Dakota, were most susceptible to wheat streak mosaic and were just about wiped out by the inocu-

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lation treatment," Timian says. "Len and Eureka also suffered more than 80 percent reductions in yield when inoculated with the disease."

In terms of percentage of yield loss when compared to plants not inoculated with the disease, Butte did best with disease losses of 26 percent. Prodax was next with a 35-percent yield reduction.

Timian suggests Butte, James, Coteau, and Prodax as good choices when growers are overseeding spring wheat into winter-killed winter wheat, planting spring wheat next to winter wheat, or in fallow land containing volunteer winter wheat.

It is not possible to predict the occurrence of wheat streak mosaic, he says, but destroying all volunteer wheat 2 weeks before planting and growing tolerant varieties will help reduce losses when the disease does occur.

Timian worked with Virgil L. Jons, ARS plant pathologist, and H. Arthur Lamey, extension plant pathologist at the university.

Roland G. Timian is located at North Dakota State University, Fargo, N. Dak. 58105.—(By Ray Pierce, Peoria, Ill.) ■

Soybean Seed Inoculation Not Always Beneficial

Farmers who inoculate seeds with nitrogen-fixing bacteria may not see yields increased if they plant on old soybean fields, according to ARS agronomist Mary Frances Sawyer.

"Old soybean fields contain inefficient strains of bacteria, and it is extremely difficult to overcome soil bacteria competitiveness on soybean roots," Sawyer says.

"However, soybean seeds inoculated with the nitrogen-fixing soil bacteria *Rhizobium japonicum* and planted where soybeans have not recently been cultivated produced increased yields. On new soybean land, the seeds definitely should be inoculated with bacteria before planting."

Sawyer's greenhouse study, done in cooperation with Auburn University at the ARS Soil and Water Research Unit there, used three different soil types to determine the bacteria inoculum rates required to compete with indigenous soil bacteria.

From the findings, it appears that up to 1,000 times the soil-bacteria population must be applied if introduced strains are to compete with indigenous strains for root-infection sites.

Mary Frances Sawyer is located at 230 Funchess Hall, Auburn Univeresity, Auburn, Ala. 36849.—(By Neal Duncan, New Orleans, La.) ■

Seed Samples Vary in Genetic Composition

Identifying bean seeds' genetic makeup by fingerprinting individual seed proteins will help scientists assure the genetic diversity of seeds held in long-term storage for breeding purposes.

Genetic diversity in plant varieties is important because it ensures that not all plants will be affected should a disease strike a crop.

Using a technique called electrophoresis, ARS plant physiologist Eric E. Roos has been able to fingerprint individual seed proteins in beans. The technique, long used to identify proteins for human medical research, has been adapted for studying genetic variation among individual seeds within a population.

According to Roos, this may be the first step toward a larger goal. "One day, we hope to use electrophoresis to identify all proteins in seeds so that it will be possible to determine how genetically diverse a whole species is," he says.

Looking at seeds, or even looking at plants grown from them, does not provide a scientific indication of genetic diversity. For example, plant introduction lines of bean seeds come in a variety of colors. Plants grown from red seeds produce not only red seeds, but other colors as well, indicating that some cross fertilization has occurred.

Most, if not all, seed samples being held for long-term preservation contain many individual seeds that vary in genetic composition. This genetic variability, with self-pollinating species such as beans, often happens merely by mixing at harvest time. Sometimes this mixing occurs during storage or regrowing to replace old seed samples.

Eric E. Roos is located at the National Seed Storage Laboratory, Colorado State University, Fort Collins, Colo. 80523.—(By Dennis Senft, Oakland, Calif.) ■